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RESEARCH MEMORANDUM

LOW-SPEED WIND-TUNNEL INVESTIGATION OF A JET CONTROL ON A 35° SWEPT WING

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RESEARCH MEMORANDUM

LOW-SPEED WIND-TUNNEL INVESTIGATION OF A JET CONTROL ON A 35° SWEPT WING

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SUMMARY

A low-speed wind-tunnel investigation was made in the Langley 300 MPH 7- by 10-foot tunnel of a jet control that obtains its effectiveness from both the jet reaction and from the change in circulation around the wing due to the jet's acting as a spoiler. The jet control was investigated as an aileron on a 35° sweptback wing of aspect ratio 4.76. The investigation was of exploratory nature and was limited to the case where the jet was supplied with air at stagnation pressure.

The results indicated that such a jet could be used as an emergency control.

INTRODUCTION

The recent emphasis on simplifying or eliminating power-boost systems required to move the controls of high-speed aircraft has led to consideration of using some part or all of the jet-engine air to provide control. In order to keep the quantity of air used to a minimum, a control system has been devised that obtains its effectiveness both from the reaction of the jet of air being ejected out of the wing and from the change in circulation about the wing resulting from the jet's acting as a spoiler. The fact that a jet of air provides changes in lift similar to a plain spoiler has been known for some time (refs. 1 to 3) but the results have been limited to two-dimensional very thick airfoils. One advantage of this type of control is that an emergency control can be obtained by using air at stagnation pressure if the jet engine fails.

The present investigation is limited to the emergency condition, that is, the only air supply is at stagnation pressure. The jet control was tested as an aileron on a 35° swept wing of aspect ratio 4.76 and at low subsonic speeds. For comparison purposes a plain spoiler was tested in conjunction with the jet.

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COEFFICIENTS AND SYMBOLS

C_L lift coefficient, $\frac{\text{Twice semispan lift}}{qS}$

C_D drag coefficient, $\frac{\text{Twice semispan drag}}{qS}$

C_m pitching-moment coefficient about 1/4-chord point of mean aerodynamic chord, $\frac{\text{Twice semispan pitching moment}}{qS\bar{c}}$

ΔC_l increment of rolling-moment coefficient produced by control, $\frac{\text{Rolling moment}}{qSb}$

q dynamic pressure, $\frac{\rho V^2}{2}$, lb/sq ft

ρ mass density of air, slugs/cu ft

V free-stream velocity, ft/sec

S twice wing area of semispan model, 13.30 sq ft

$\bar{c}$ mean aerodynamic chord, 1.73 ft

c local wing chord, ft

b twice span of semispan model, 7.96 ft

α angle of attack, deg

M Mach number

R Reynolds number of wing based on $\bar{c}$

δ_s spoiler projection, percent c

$\frac{pb}{2V}$ wing-tip helix angle, radians

p rolling angular velocity, radians/sec

APPARATUS AND MODEL

The semispan-sweptback-wing model was mounted in the Langley 300 MPH 7- by 10-foot tunnel adjacent to the ceiling of the tunnel, the ceiling thereby serving as a reflection plane. The model was mounted on the balance system in such a manner that all forces and moments acting on the model could be measured. A small clearance was maintained between the model and the tunnel ceiling so that no part of the model came in contact with the tunnel structure. A small end plate was attached to the model root to deflect the air that flows into the tunnel test section through the clearance hole between the model and the tunnel ceiling so as to minimize the effects of any such inflow on the flow over the model.

The model geometry is shown in figure 1. Some details of the jet control are shown in figure 2. The store underneath the wing picked up stream stagnation air and fed it into the wing chamber where it was exhausted through a slot on the upper surface of the wing (see section A-A of fig. 2). No provision was made for equalizing the pressure across the span of the chamber. The jet slot was directed forward 30° from a line normal to the wing surface at the slot. The front edge of the variable-width slot was located along the 0.7c line of the wing. The plain spoiler used in conjunction with the jet was located adjacent to the leading edge of the jet slot and was inclined forward 30° the same as the jet slot. The spoilers were made of 1/32-inch brass with heights of 1.5, 3, and 6 percent of the wing chord and had the same span as the jet slot.

TESTS

The tests were run at an average dynamic pressure of approximately 112.8 pounds per square foot, which corresponds to a Mach number of about 0.27 and a Reynolds number of about 3,500,000 based on the wing mean aerodynamic chord of 20.77 inches.

Most of the tests were run through an angle-of-attack range from 0° to 20°. Tests were made with three different jet gaps, with plain spoilers of three heights, and with the plain spoilers in conjunction with the jet.

CORRECTIONS

Blockage corrections as determined from reference 4 to account for the constriction effects of the model on the tunnel free-stream flow have been applied to the data. Jet-boundary corrections as determined by the method of reference 5 have been applied to the drag and angle of attack. No reflection-plane corrections have been applied to the rolling-moment coefficients.

RESULTS AND DISCUSSION

The aerodynamic characteristics of the wing without control (fig. 3) are presented for reference purposes only and will, therefore, not be discussed in this paper.

The results of the jet supplied with air at stagnation pressure, figure 4(a), indicate that the jet is effective in producing rolling moment throughout the angle-of-attack range tested. The variation of rolling-moment coefficient with jet-gap width indicates that variation of the jet gap is a satisfactory means of varying the control effectiveness. The magnitude of the rolling-moment coefficient for this small-span control would provide a $pb/2V$ of about 0.01. If the span of control were about $0.70b/2$ this would be raised to 0.025 or 0.03 which should be adequate for emergency operation but would not be sufficient for operational flight.

Plain spoilers located at the same chordwise location and having the same span as the jet (fig. 4(b)) are included to evaluate the rolling performance of the jet. The results indicate that the 1/4-inch-gap jet has about the same effectiveness as the 3-percent-chord spoiler at low angles of attack but does not exhibit as large a loss in effectiveness as do the plain spoilers at high angles of attack. Using the jet in combination with the spoilers (fig. 4(c)) increases the control effectiveness considerably. In fact calculations made from the results for the 1/8-inch-gap jet and the 3-percent-chord spoiler indicate that if the control had a span of three times that tested sufficient control would be available for operational flight. This arrangement is such that the spoiler could be of the simple circular-arc type and be deflected proportional to the increase in jet gap.

CONCLUDING REMARKS

The results of the exploratory investigation of a jet control on a 35° swept wing indicate that the air at stagnation pressure should provide adequate control for emergency flight for a system where normal control is obtained by using a jet of air at high pressure or where a spoiler is used in conjunction with the jet at stagnation pressure.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., August 26, 1953.

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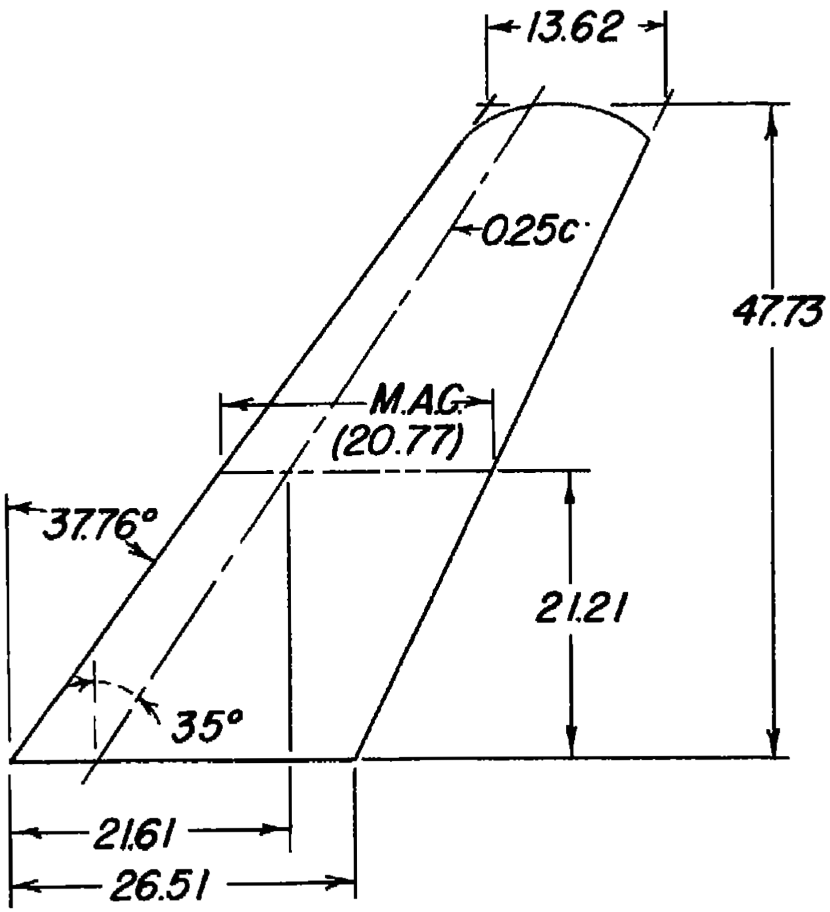

TABULATED WING DATA

Area (twice semispan)	13.30 sq ft
Aspect ratio	4.76
Taper ratio	0.51
Airfoil section	NACA 65,012 mod.

Figure 1.- Geometric characteristics of 35° sweptback wing. (All dimensions are in inches unless otherwise noted.)

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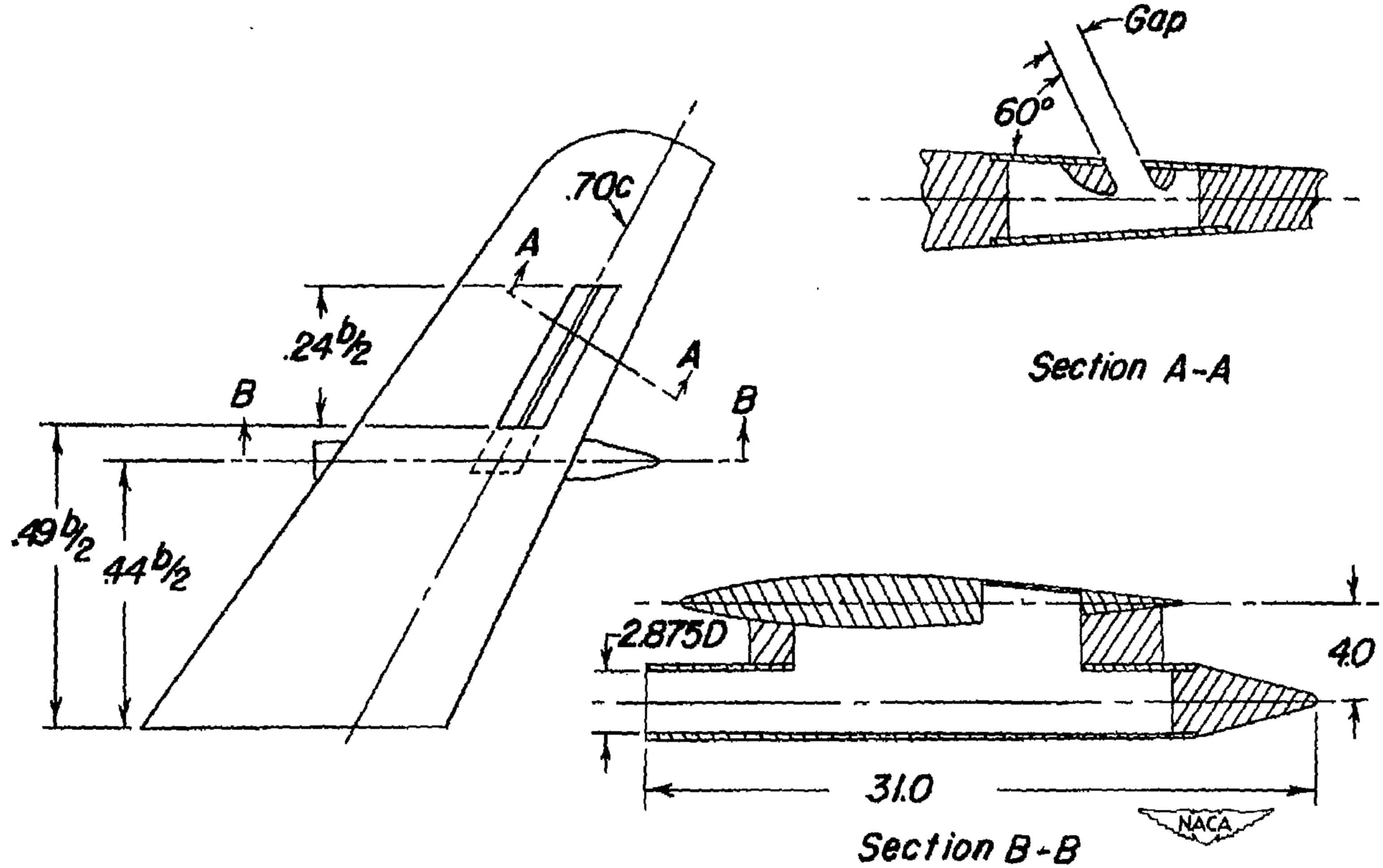


Figure 2.- Details of jet control.

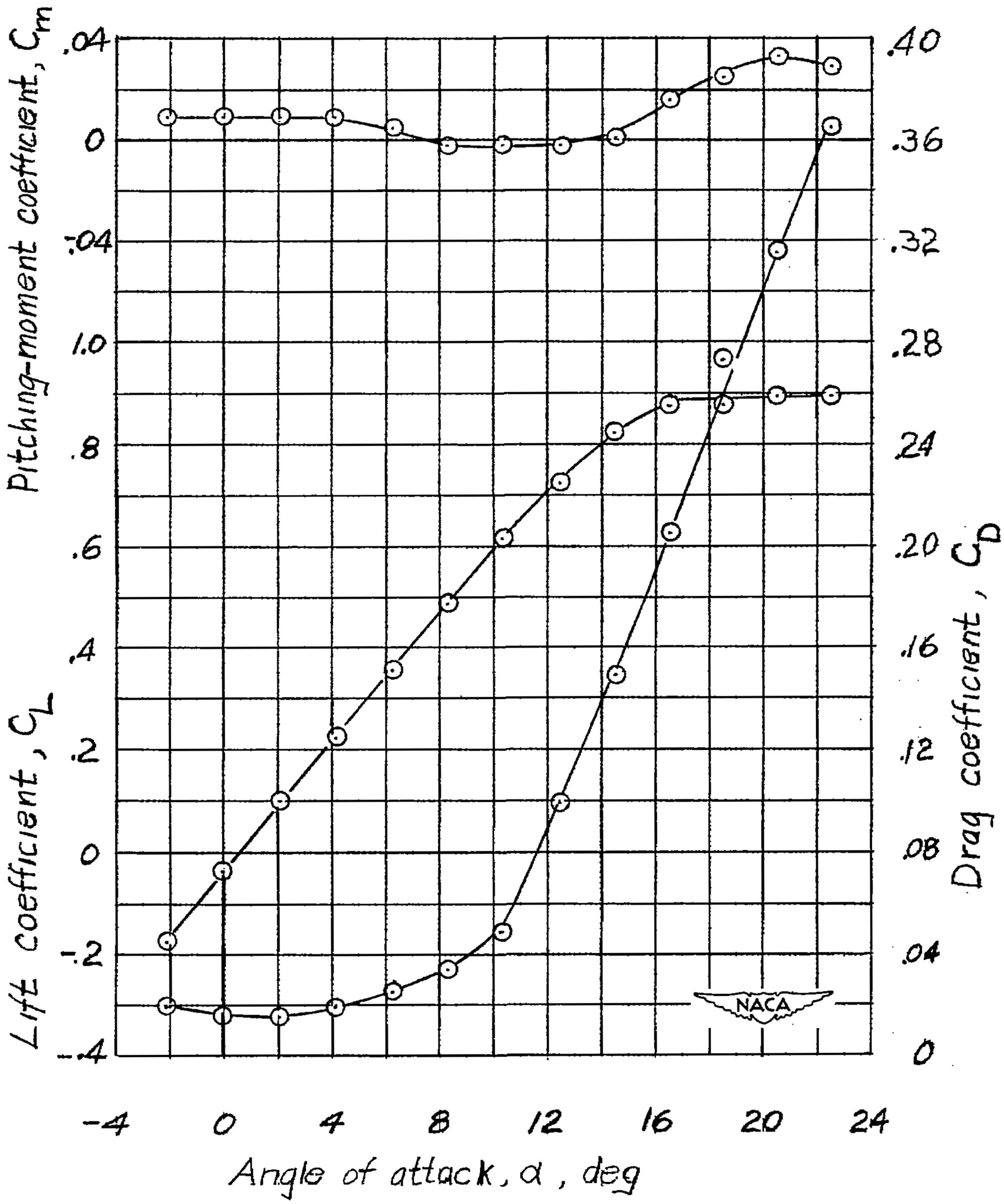
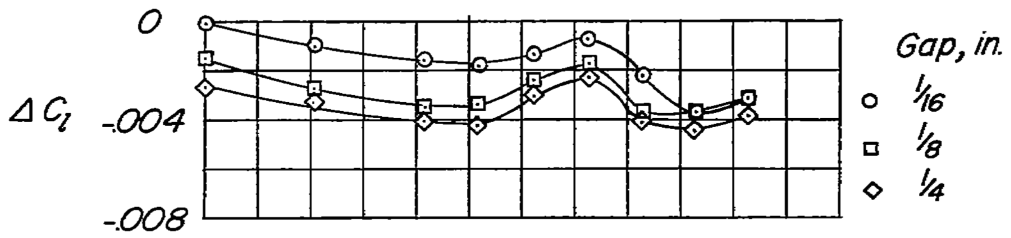
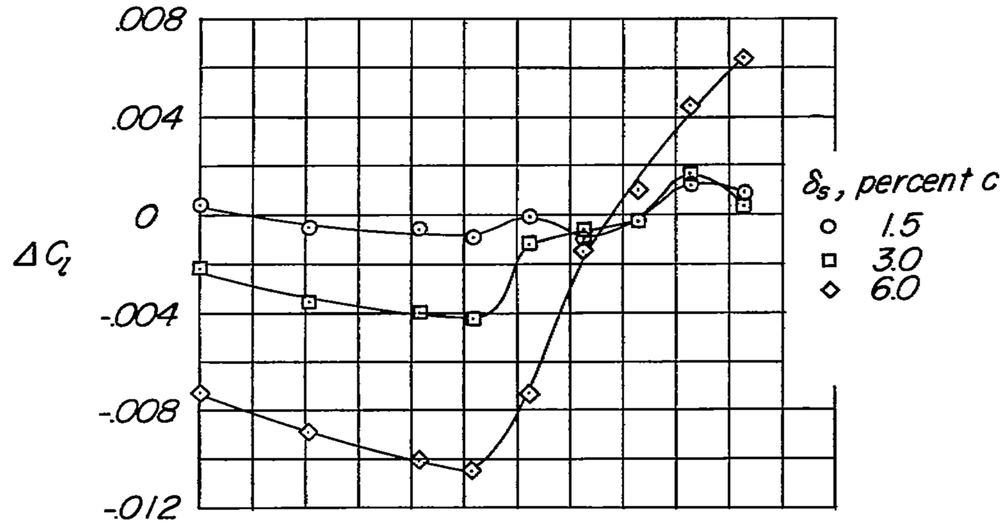


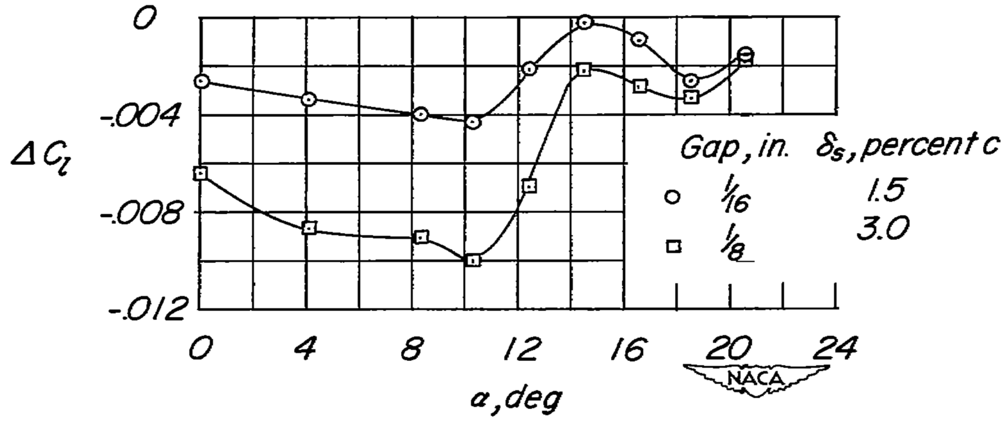
Figure 3.- Aerodynamic characteristics of the wing with store installed.



(a) Jet.



(b) Spoiler.



(c) Jet-spoiler combination.

Figure 4.- Rolling-moment characteristics of a jet, a spoiler, and a jet-spoiler combination on a 35° sweptback wing.

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SECURITY INFORMATION

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